

Amendments to Specification

Please amend the specification starting at page 8, line 14 through page 13, line 2 as follows:

While it is normal practice to utilize a transparent electrode such as ITO at the side of the device where light is emitted, in order to minimize transmission losses through the electrode the present invention replaces or augments the transparent electrode with a thin layer of high reflectivity metal layer ~~126~~ 122 to increase the efficiency of the device. As best seen in Figure 1, the anode 120 can be a composite layer, made up of the semi-transparent layer ~~126~~ 122 and the passivation layer 128 of conductive polymer coated on the second surface 124 of the semi-transparent layer ~~126~~ 122.

In a first alternate embodiment (not shown), the anode includes only a conductive, current carrying layer that can serve as a hole-injecting layer, and does not include a passivation layer. In a second alternate embodiment (not shown), the anode includes a transparent conductive layer such as ITO adjacent to the first surface 124 of the semi-transparent layer ~~126~~ 122 as well as the passivation layer 128. In a third alternate embodiment (not shown), the anode includes a transparent conductive layer such as ITO adjacent to the first surface 124 of the semi-transparent layer ~~126~~ 122 and does not include a passivation layer. The semi-transparent layer ~~126~~ 122 of the composite anode 120 or the alternative single anode layer (not shown) is made of an anode material selected from the group of high reflectivity metals of high work function (typically greater than about 4.0 eV). Examples of suitable metals include silver, gold, aluminum and copper. In a preferred embodiment, the semi-transparent layer ~~126~~ 122 has a reflectivity of at least 91.4% at emission wavelength, is a good electrical conductor (having a conductivity of from about 10^2 to about $10^8 \Omega^{-1} \text{ cm}^{-1}$, and being capable of forming into a smooth, contiguous film. In a second preferred embodiment, the semi-transparent layer has a reflectivity of more than about 92% at the wavelength emission. In a third preferred embodiment, the semi-transparent layer has a reflectivity of between about 92% and about 96.5% at the wavelength emission. In a fourth preferred embodiment, the semi-transparent layer has a reflectivity of between about 94% and about 96.5% at the wavelength emission. In a fifth preferred

embodiment, the semi-transparent layer 126 122 has reflectivity greater than about 96% at the wavelength emission. In another preferred embodiment, the semi-transparent layer 126 122 has a reflectivity of at least 86% at an emission wavelength of from 400 nm to 500 nm. Examples of such anode material include silver, aluminum, gold and copper, as well as alloys of such metals.

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cont. The semi-transparent layer 126 122 can typically be fabricated using any of the techniques known in the art for deposition of thin films, including, for example, vacuum evaporation, sputter deposition, electron beam deposition, or chemical vapor deposition, using for example, pure metals or alloys or other film precursors. The thickness of the metal layer can be controlled by the rate and time of evaporation/deposition. A typical rate of evaporation/deposition is about 0.5 to 10 Å/sec. The thickness of the semi-transparent layer should be thin enough to transmit at least some light (so that it is semi-transparent), and thick enough to provide a continuous layer. Typically, the semi-transparent metal layer 126 122 has a thickness of from about 100 Å to about 500 Å. In a first preferred embodiment, the semi-transparent layer has a thickness of from about 250 to about 400 Å. In a second preferred embodiment, the semi-transparent layer has a thickness of from about 275 to about 350 Å. In a third preferred embodiment, the semi-transparent layer has a thickness of from about 275 to about 325 Å.

The optional passivation layer 128 of conductive material enables the use of high reflectivity metals with work functions that are not precisely matched with the emissive polymers being utilized. The exact form of conductive material useful in this invention may vary widely and is not critical. Examples of suitable conductive material include, but are not limited to, poly(aniline), poly(aniline) blends, polythiophenes, and polythiophene blends. Useful conductive poly(anilines) include the homopolymer, derivatives and blends with bulk polymers. Examples of useful poly(aniline) include those disclosed in U.S. Patent No. 5,232,631 and U.S. Patent No. 5,723,873. Useful conductive polythiophenes include the homopolymer, derivatives and blends with bulk polymers. Examples of useful polythiophenes include poly(ethylenedioxythiophenes) (PEDT), such as poly(3,4-ethylenedioxythiophene, and those disclosed in U.S. Patent No. 5,766,515 and U.S. Patent No. 5,035,926. The term "polyaniline" and "polythiophenes" are used herein generically to include substituted and unsubstituted materials. It is also used in a

manner to include any accompanying dopants, particularly acidic materials used to render the material conductive.

Cathode

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The first cathode layer 142 is selected from low work function metals or low work function metal-oxides (typically less than about 3.5 eV). Examples of suitable low work function materials include alkali, alkaline earth and lanthanide metals and oxides of alkali, alkaline earth and lanthanide metals. The term “alkali metal” is used herein in the conventional sense to refer to elements of Group IA of the periodic table. The term “alkali metal oxide” is used herein in the conventional sense to refer to compounds of an alkali metal and oxygen. For convenience, alkali metal oxides are referred to herein by the chemical formula of the corresponding simple oxide (*e.g.*, Li_2O , Na_2O , K_2O , Rb_2O , and Cs_2O); however, this reference to the simple oxide is intended to encompass other oxides, including mixed oxides and non-stoichiometric oxides (*e.g.*, Li_xO , Na_xO , K_xO , Rb_xO , and Cs_xO , where x is from about 0.1 to about 2).

The term “alkaline earth metal” is used herein in the conventional sense to refer to elements of Group IIA of the periodic table. Preferred alkaline earth metals include magnesium (*i.e.*, Mg), calcium (*i.e.*, Ca), strontium (*i.e.*, Sr), and barium (*i.e.*, Ba). The term “alkaline earth metal oxide” is used herein in the conventional sense to refer to compounds of an alkaline earth metal and oxygen. For convenience, alkaline earth metal oxides are referred to herein by the chemical formula of the corresponding simple oxide (*e.g.*, MgO , BaO , CaO , SrO , and BaO); however, this reference to the simple oxide is intended to encompass other oxides, including mixed oxides and non-stoichiometric oxides (*e.g.*, Mg_xO , Ba_xO , Ca_xO , Sr_xO , and Ba_xO , where x is from about 0.1 to about 1).

The term “lanthanide metal” is used herein in the conventional sense to refer to elements of the lanthanide series of the periodic table, from cerium (*i.e.*, Ce) through lutetium (*i.e.*, Lu). Preferred lanthanide metals include samarium (*i.e.*, Sm), Ytterbium (*i.e.*, Yb), and neodymium (*i.e.*, Nd). The term “lanthanide metal oxide” is used herein in the conventional sense to refer to compounds of a lanthanide metal and oxygen. For convenience, lanthanide metal oxides are referred to herein by the chemical formula of the corresponding simple oxide of the +3 valency state (*e.g.*, Sm_2O_3 , Yb_2O_3 , and Nd_2O_3); however, this reference to the simple oxide is

intended to encompass other oxides, including mixed oxides and non-stoichiometric oxides (e.g., Sm_xO , Yb_xO , and Nd_xO), where x is from about 0.1 to about 1.5.

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In a preferred embodiment, first cathode layer 142 includes low work function metal oxides. The first cathode layer 142 can typically be deposited by thermal vacuum evaporation. Typically, the first cathode layer 142 has a thickness of from about 10 to 200 Å. A typical rate of evaporation/deposition is from about 0.2 to about 4 Å per second.

Like the semi-transparent layer ~~126~~ 122, the second cathode layer 144 has a high reflectivity and a high work function, and is made of a material that can be formed into a smooth, contiguous film. Typically the second cathode layer 144 has a work function of greater than 4 eV. In a preferred embodiment, the second cathode layer 144 has a reflectivity of at least 91.4% at emission wavelength. In a second preferred embodiment, the second cathode layer has a reflectivity of between 92% and 96.5% at the wavelength emission. In a third preferred embodiment, the second cathode layer has a reflectivity of between 94% and 96.5% at the wavelength emission. In a fourth preferred embodiment, the reflectivity of the second cathode layer is more than 96% at the wavelength emission. In another preferred embodiment, a metal that has a reflectivity of at least 86% at an emission wavelength of from 400 nm to 500 nm is used as the second cathode layer 144. As with the semi-transparent layer ~~126~~ 122, the second cathode layer 144 includes a cathode material selected from metals and metal alloys. Examples of suitable high work function metals include aluminum, silver, copper, gold and the like, as well as alloys of such metals.

A preferred embodiment uses metal or metal alloy that has a reflectivity of at least 91.4% at the emission wavelength as both the semi-transparent layer ~~126~~ 122 and as the second cathode layer 144. In another preferred embodiment, a metal that has a reflectivity of at least 86% at an emission wavelength of from 400 nm to 500 nm are used as both the semi-transparent layer ~~126~~ 122 and as the second cathode layer 144.

In general, the second cathode layer 144 need not be the same material as used for the semi-transparent layer ~~126~~ 122. For example, gold could be used for the high work function semi-transparent anode, and silver could be used as the high reflectivity metal layer in the bilayer cathode. In a preferred embodiment, the high

reflectivity layer 142 has a metal with a reflectivity of at least 91.4%, or a reflectivity of at least 86% at an emission wavelength of from 400 nm to 500 nm, as both the second cathode layer 144 and as the semi-transparent layer ~~126~~ 122. In a more preferred embodiment, silver (Ag) is used as both the high reflectivity metal layer in the bilayer cathode and as the semi-transparent anode.

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encl. Optionally, a multi-layer cathode system (not shown) can be used. For example, a first layer of high reflectivity cathode layer (preferably, of sufficient thickness to be opaque) may be covered by a layer of another high reflectivity cathode layer, which may be more or less reflective than the first high reflectivity cathode layer. In a tri-layer cathode-capping configuration, the uppermost metal may be any stable metal capable of forming a smooth, contiguous film, for example, aluminum or aluminum alloy. Subsequent layers can be added for specific function such as for example, for passivating and sealing of the device. Examples of layers useful for sealing the device include an air-stable capping layer. The term "air-stable" refers to the ability to protect the layers underneath the capping layer from ambient oxygen and moisture that may be present around the device. Suitable materials for air-stable capping layer include a metal or metal alloy.

As with the semi-transparent layer ~~126~~ 122, the second cathode layer 144 can be fabricated using known deposition techniques. A typical rate of evaporation/deposition is from about 1 to 20 Å/sec. The thickness of the second cathode layer 144 should be thick enough to cover the first cathode layer and be opaque enough to give high reflectivity at the wavelength of interest. Typically, the second cathode layer has a thickness of at least about 800 Å.
